ROTARY ELECTRIC MACHINE, LINEAR MOTOR AND STATOR THEREOF

BACKGROUND OF THE INVENTION

The present invention relates to a rotary electric machine, a linear motor and a stator used for them.

In a stator of a rotary electric machine of which armature windings are constructed in a single layer distributed winding and contained in a 3-phase-6-pole stator core having 36 slots, 2 slots per pole per phase, as shown in FIG. 8 and FIG. 9, the stator comprises a stator core 1 which has a back yoke portion 1a formed in a cylindrical shape; a plurality of tooth portions 1b projecting from inner peripheral face of the back yoke portion 1a toward the center; and the slots 2 each formed between the tooth portions 1b, and the plurality of armature windings 3 formed in a ring shape are arranged and contained in the slots 2 in an arbitrary slot pitch.

The end coil portion of the armature winding 3 of the rotary electric machine is arranged in a form of being pushed and bent into a space near the side face of the back yoke portion 1b of the stator core 1.

In the stator having the armature windings 3 single layer wounded as described above, winding work is performed by initially containing the windings U1, U2... in the outer peripheral (back bottom) side of the slot 2, and then by containing the windings V1, V2... in the inner peripheral side of the slot 2, and finally by containing the windings

W1, W2... in the innermost peripheral side of the slot 2 (therein, the reference character attached to individual windings of U, V, W express the windings for U-phase, V-phase and W-phase, respectively). In the winding work, the individual coil end portions of the windings are arranged in the side face of the back yoke portion 1a of the stator core 1, and the coil end portions of the windings W1, W2... finally contained are arranged onto the upper side of the coil end portions of the windings U1, U2..., W1, W2... for V-phase and W-phase.

In the coil end portions of the windings in the side face of the back yoke portion 1a of the stator core 1, the height (dimension of the projected portion) H2 of the coil end portion becomes high because the end portions are overlapped over one phase on the other phase, as shown in FIG. 10 (b).

Therefore, the axial dimension L2b of the stator, that is, the sum of the projected dimension H2 of the coil end portions and the thickness dimension L2a of the stator core 1 becomes large. Therein, the reference character 4 indicated a rotor shaft.

In a linear motor, this means that the width dimension of the linear motor becomes large.

SUMMARY OF THE INVENTION

An object of the present invention is to reduce an axial dimension or a width dimension of a stator by

reducing the projected dimension of the end coil portions of the windings contained in the stator core.

Another object of the present invention is to further reduce the wiring work cost and the material cost.

The present invention is characterized by a stator comprising a stator core having an even number of slots per pole per phase; and armature windings contained in the slots, the armature windings being wounded in a single layer distributed winding, wherein one of the slot arranged between two of the slots containing a first armature winding contains a second armature winding for a phase different from a phase of the first armature winding, and one of the slot arranged between the two of slots containing the first armature winding contains a third armature winding for a phase equal to the phase of the second armature winding, and one of the second armature winding and the third armature winding is arranged in a coil end portion in an outer peripheral side of the first armature winding, and the other is arranged in an inner peripheral side of the first armature winding.

Further, the stator is characterized by that the stator is constructed by partially performing winding work of the armature windings to a plurality of divided cores formed by laminating segments stamped in a sector; and then assembling the plurality of divided cores into a cylindrical shape and containing the armature windings spreading over the divided cores into the individual slots.

Further, the stator is characterized by that an axial dimension of the stator including the stator core and the coil end portions is reduced by arranging the coil end portions in a space near a side face of a back yoke portion.

Furthermore, a rotary electric machine is constructed using the stator described above and a rotor which is held so as to be arranged opposite to the stator. A linear motor is constructed using the stator described above and a mover which is held so as to be arranged opposite to the stator.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic view showing the side face of a stator in a first embodiment of a rotary electric machine in accordance with the present invention:

FIG. 2 is a wiring diagram showing the armature windings to the stator in the rotary electric machine shown in FIG. 1:

FIG. 3 is a schematic view showing the side face of a stator in a second embodiment of a rotary electric machine in accordance with the present invention:

FIG. 4 is a wiring diagram showing the armature windings to the stator in the rotary electric machine shown in FIG. 3:

FIG. 5 is a schematic view showing the side face of a stator in a third embodiment of a rotary electric machine in accordance with the present invention:

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stator in a fourth embodiment of a rotary electric machine in accordance with the present invention:

FIG. 7 is a schematic view showing the side face of a stator in a fifth embodiment of a linear motor in accordance with the present invention:

FIG. 8 is a schematic view showing the side face of a stator in a conventional rotary machine:

FIG. 9 is a wiring diagram showing the armature windings to the stator in the rotary electric machine shown in FIG. 8: and

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FIG. 10 is a plan view explaining the dimension in an axial direction of a stator of a rotary electric machine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A rotary electric machine or a linear motor in accordance with the present invention comprises a stator having armature windings and a movable part such as a rotor or a mover held so as to be arranged opposite to the stator though the rotary electric machine or the linear motor is not illustrated as a drawing in the present specification. The movable part comprises secondary electric conductors in a case of an induction motor or magnetic poles in a case of synchronous motor.

In a machine performing speed control or position control, electric power is supplied to the armature windings using an inverter circuit.

The present invention characterizes the stator in

such a rotary electric machine or a linear motor, and embodiments of the stator will be described below, referring to the accompanied drawings.

(First Embodiment)

FIG. 1 is a schematic view showing the side face of a stator in a first embodiment of a rotary electric machine in accordance with the present invention. FIG. 2 is a wiring diagram showing the armature windings to the stator in the rotary electric machine. The first embodiment of the stator is a stator containing the single layer distributed wound armature windings 3 in a 3-phase-6-pole stator core having 36 slots, 2 slots per pole per phase.

Referring to FIG. 1 and FIG. 2, similarly to a conventional stator core, the stator core 1 comprises a back yoke portion 1a formed in a cylindrical shape; a plurality of tooth portions 1b projecting from inner peripheral face of the back yoke portion 1a toward the center; and the slots 2 each formed between the tooth portions 1b.

The armature windings 3 are contained into the individual slots 2 so as to be arranged in order of the winding U1 for U-phase, the winding W1 for W-phase, the winding V1 for V-phase, the winding U2 for U-phase, the winding W2 for W-phase, the winding V2 for V-phase... (contained in order of U1, W1, V1, U2, W2, V2, ...Un, Wn, Vn).

This arrangement of the windings is formed as follows. The winding U1 to be contained first is contained into the slots 2 of slot number 1 and slot number 6 of the stator core 1, and the winding W1 to be contained next is contained into the slots 2 of slot number 3 and slot number 8 of the stator core 1. However, in regard to the containing of the windings into the slots 2 of slot number 1 and slot number 3, the windings are temporarily put on the slots. After that, the winding work is successively performed to contain the winding V1 into the slots of slot number 5 and slot number 10, the winding U2 into the slots of slot number 7 and slot number 12, the winding W2 into the slots of slot number 9 and slot number 14, the winding V2 into the slots of slot number 11 and slot number 16 until the winding U6. After the winding W6 and the winding V6 are contained into the slots of slot number 2 and slot number 4, the winding U1 temporarily put to be contained into the slot of slot number 1 and the winding W1 temporarily put to be contained into the slot of slot number 3 are rearranged to be contained into the corresponding slots 2.

When the dimension of the outer axial length of the rotary electric machine is shortened, the dimension of the above-mentioned projected coil end portions are decreased by pushing and bending the coil end portions of the windings 3 toward the space near the side face of the back yoke portion 1a of the stator core 1 like a file of

dominoes.

After all, the stator constructed as described above comprises a stator core having an even number of slots per pole per phase; and armature windings contained in the slots, the armature windings being wounded in a single layer distributed winding, wherein one of the slot arranged between two of the slots containing a first armature winding contains a second armature winding for a phase different from a phase of the first armature winding, and one of the slot arranged between the two of slots containing the first armature winding contains a third armature winding for a phase equal to the phase of the second armature winding, and one of the second armature winding and the third armature winding is arranged in a coil end portion in an outer peripheral side of the first armature winding, and the other is arranged in an inner peripheral side of the first armature winding. As the result, the axial dimension of the stator can be reduced by decreasing the projected dimension of the coil end portions of the windings contained in the stator core.

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(Second Embodiment)

FIG. 3 is a schematic view showing the side face of a stator in a first embodiment of a rotary electric machine in accordance with the present invention. FIG. 4 is a wiring diagram showing the single layer distributed wound armature windings to the stator in the rotary electric

machine. The second embodiment of the stator is a stator containing the single layer distributed wound armature windings in a 3-phase-6-pole stator core having 36 slots, 2 slots per pole per phase.

The shape of the stator core 1 is the same as the stator core 1 in the first embodiment. Further, the armature windings 3 are contained into the individual slots 2 so as to be arranged in order of the winding U1 for U-phase, the winding W1 for W-phase, the winding V1 for V-phase, the winding U2 for U-phase, the winding W2 for W-phase, the winding V2 for V-phase... (contained in order of U1, W1, V1, U2, W2, V2, ...Un, Wn, Vn).

In this embodiment, the arrangement of the windings is formed as follows. The winding U1 to be contained first is normally contained into the slots 2 of slot number 1 and slot number 6 of the stator core 1, and the winding W1 to be contained next is also normally contained into the slots 2 of slot number 3 and slot number 8 of the stator core 1. After that, the winding work is successively performed to contain the winding V1 into the slots of slot number 5 and slot number 10, the winding U2 into the slots of slot number 7 and slot number 12, the winding W2 into the slots of slot number 9 and slot number 14, the winding V2 into the slots of slot number 11 and slot number 16 until containing the winding U6. The winding W6 and the winding V6 are contained into the slots of slot number 2 and slot number 4 through the above portions of the coil end

portions of the winding U1 contained in the slot of slot number 1 and the winding W1 contained in the slot of slot number 3, respectively.

Similarly, in this stator, when the dimension of the outer axial length of the rotary electric machine is shortened, the dimension of the above-mentioned projected coil end portions are decreased by pushing and bending the coil end portions of the windings 3 toward the space near the side face of the back yoke portion 1a of the stator core 1 like a file of dominoes.

FIG. 10 is a plan view explaining the axial dimension of the stator in the first and the second embodiments which is illustrated so as to be compared with the axial dimension of the conventional rotary electric machine.

Referring to FIG. 10 (a), the height H1 of the coil end portion can be formed lower than the height H2 of the coil end portion of the stator wounded using the conventional technology shown in FIG. 10 (b). Therefore, the total axial length L1b of the rotary electric machine including the axial length L1a of the stator core and the heights of the coil end portions can be reduced, and accordingly the thickness of the rotary electric machine can be made thinner.

(Third Embodiment)

Although the first and the second embodiments have shown the examples that the number of slots per pole and

per phase is two, in cases where the number of slots per pole and per phase is 4, 6, 8..., the same effect can be attained by similarly applying the present invention. As one of the examples, description will be made on a rotary electric machine using a stator containing the armature windings in a 3-phase-4-pole stator core having 48 slots, 4 slots per pole per phase.

FIG. 5 is a schematic view showing the side face of a stator in a third embodiment of a rotary electric machine in accordance with the present invention. The third embodiment of the stator has the structure that the stator contains the single layer distributed wound armature windings 3 in a 3-phase-4-pole stator core having 48 slots, 4 slots per pole per phase.

Each of the windings U1 to V4 for individual phases and poles comprises two coaxially wounded coils 3a, 3b, and the two coils 3a, 3b for each pole of the windings U1 to V4 are individually contained into two slots adjacent to each other. That is, the two coils of the winding U1 for U-phase are contained in the slots 2 of slot numbers 1, 2, 11 and 12, and the two coils of the winding W1 for W-phase are contained in the slots 2 of slot numbers 5, 6, 15 and 16, and the two coils of the winding V1 for V-phase are contained in the slots 2 of slot numbers 9, 10, 19 and 20 (and so forth).

Although the winding method employed in the second embodiment is employed in this embodiment, the winding

method of the first embodiment may be amployed.

Similarly, when the dimension of the outer axial length of the rotary electric machine is shortened, the dimension of the above-mentioned projected coil end portions are decreased by pushing and bending the coil end portions of the windings 3 toward the space near the side face of the back yoke portion 1a of the stator core 1 like a file of dominoes.

(Fourth Embodiment)

In the fourth embodiment, the stator core is composed of a plurality of divided cores by laminating segments stamped in a sector, and then partially setting the windings to the divided cores through the winding method of the above-described embodiment, and after that assembling the plurality of divided cores into a cylindrical shape and containing the armature windings spreading over the divided cores into the individual slots.

FIG. 6 is a schematic view showing the side face of a stator in the fourth embodiment of a rotary electric machine in accordance with the present invention. The fourth embodiment of the stator comprises the stator core which is composed of three divided cores 11, 12, 13 formed by laminating segments stamped in a sector. The windings 30 are partially set to the divided cores 11 to 13 through the winding method of the second embodiment, and after that the divided cores 11 to 13 are joined to form in a

cylindrical shape and at the same time the armature windings 31, 32 spreading over the divided cores are contained into the individual slots.

FIG. 6 (a) shows the state that windings has been partially wounded to one of the sectorial divided cores 11. As the method of winding in this embodiment, the method of winding in the second embodiment is employed. The windings are similarly set to the other divided cores 12 and 13.

FIG. 6 (b) shows the state of assembling the three divided cores 11 to 13 having partially set windings to the cylindrical stator core 10. In regard to the method of containing the windings 31 spreading over the divided portion and entering into the slots 20 in the end portion of the adjacent divided core and the windings 32 entering into the slot 20 in the end portion of the own divided core, there are two methods, that is, a method of containing the winding by exchanging and a method of containing the winding not by exchanging. Which method should be employed may be selected depending on a status of working place. In the other words, which method should be employed is determined by which winding arrangement is selected, the winding arrangement shown by the first embodiment or the winding arrangement shown by the second embodiment.

Since the winding work to the divided cores 11 to 13 formed by laminating the segments stamped in the sector can be performed in an open and wide work space, the workability is better than that of the winding work to the

stator core 10 of one-piece structure performed in a closed and narrow work place, and accordingly a ratio of constituting the winding cross section in the slot (a share of the windings) can be increased. Further, since the stator core 10 is constructed by assembling the divided cores 11 to 13, the sectorial segments composing each of the divided cores 11 to 13 can be stamped with a good yield to improve the use factor of the core material and to reduce the material cost.

Further, when the dimension of the outer axial length of the rotary electric machine is shortened, the dimension of the above-mentioned projected coil end portions are decreased by pushing and bending the coil end portions of the windings 3 toward the space near the side face of the back yoke portion 1a of the stator core 1 like a file of dominoes.

(Fifth Embodiment)

The structure of arranging the armature windings in the stator in accordance with the present invention can be similarly applied to the stator in a linear motor. The fifth embodiment is a stator in a linear motor which is a form of expanding the cylindrical stator of the first embodiment of the rotary electric machine.

FIG. 7 is a schematic view showing the side face of the stator in the fifth embodiment of the linear motor in accordance with the present invention.

Referring to FIG. 7, similarly to a conventional stator core, a stator core 41 comprises a back yoke portion 41a; a plurality of tooth portions 41b extending from the upper face of the back yoke 41a; and slots 50 formed between the tooth portions 41b.

The armature windings 60 are contained into the individual slots 50 so as to be arranged in order of the winding U1 for U-phase, the winding W1 for W-phase, the winding V1 for V-phase, the winding U2 for U-phase, the winding W2 for W-phase, the winding V2 for V-phase... (contained in order of U1, W1, V1, U2, W2, V2, ...Un, Wn, Vn). The arrangement of the windings 60 is similar to that of the first embodiment.

When the dimension of the outer axial length of the linear motor is shortened, the dimension of the above-mentioned projected coil end portions are decreased by pushing and bending the coil end portions of the windings 60 toward the space near the side face of the back yoke portion 41a of the stator core 41 like a file of dominoes.

According to the present invention, the dimension of the projected coil end portions in the axial direction or the width direction can be decreased, and accordingly the thickness of the rotary electric machine can be made thin and the width of the linear motor can be decreased.

Further, by employing the divided core, the winding work can be improved and the use factor of the core material can be improved, and the work cost and the

material cost can be reduced.